

Surgery re-imagined: The digital revolution

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Anaesthesia and asepsis made surgery humane and safe in the latter half of the nineteenth century. The twentieth century brought laparoscopy, open-heart surgery, organ transplant and surgical staplers, amongst other advances. Today, the digital revolution is ushering in a new era in surgery. While some contend that this might serve to further dehumanize medicine, there is no denying that the smart deployment of technology can improve surgical safety and precision as well as improve the well-being of those it serves.

September 7th, 2001 was like any ordinary Friday. Dr. Michel Gagner, Chief of Laparoscopic Surgery at New York Mount Sinai Hospital had a scheduled surgery. The operation was a cholecystectomy on a 68-year-old female, a procedure he had done thousands of times. Despite that, he felt nervous.¹ It felt as if the entire world was watching him. A new era was about to begin: technology was set to make geography inconsequential to the safe delivery of surgical care. The doctor was in New York. His patient in Strasbourg, France. Over 4,000 miles separated the two. What followed was a successful 45-minute cholecystectomy performed on a robot named Zeus. Collaboration between scientists at the University of California and engineers from the French Telecom ensured a stable connection. The project, aptly named Lindberg after the first American aviator who flew solo across the Atlantic, was a huge success.

Consider the changes that have occurred since 2001: billions of smartphones and the development of other sophisticated devices have enhanced connectivity in ways that were unimaginable. Surgical robots were a novelty. Now, just the da Vinci Surgical System has over 5500 units worldwide. Google, Medtronic and others are developing their versions. In addition, 5G networks have minimised latencies and made fast transmission of data safe and reliable. This technology was recently used in China where a surgeon operated on the liver of a laboratory animal several miles away using 5G to control the robotic arms with extremely low latency.² This means that what was a unique event in 2001 is much closer to

becoming a part of routine surgical practice today.

Digital technologies have also made their way into the operating room. Surgical robotic systems like the da Vinci provide users with more dexterity and magnified 3D optics, wristed instruments with tremor filtration and seven degrees of freedom. They also improve the ability to perform complex minimally invasive procedures by allowing access to deep anatomical structures on a stable platform. Some elements of an operation can even be delegated to the robot. For example, the Smart Tissue Autonomous Robot (STAR) not only performs linear suturing, it is also able to execute a tension free sutured bowel anastomosis with better fidelity than a human being.³ Other advanced instruments that provide haptic feedback to the surgeon enable better tissue handling. Enhanced visualisation in high definition allows both surgeons and assistants the ability to identify critical structures and keep them out of harm's way during complex operations. The use of Near-Infrared (NIR) imaging technology adds another layer of precision. NIR technology using fluorescent dyes is now commonly used to assess perfusion in gastrointestinal anastomoses, with excellent reported outcomes in colorectal surgery.⁴

This advancement in technology has also meant that our ability to generate data has grown exponentially. It is estimated that just one minute of a high-definition surgical video contains 25 times the amount of information in one CT scan image.⁵ Enhanced computing and processing capabilities have enabled enormous amounts of medical data to be stored and analyzed. This makes it possible for machines to recognise patterns, learn from repetition, improve their predictive accuracy and theoretically eliminate 'human' error. This forms the basis for the concept of Artificial Intelligence (AI) in health care and its subsidiary, machine learning (ML). These are no longer some futuristic Hollywood-type fantasies. AI algorithms have been shown to perform as well as trained physicians in diagnosing intracranial haemorrhages on CT scans, breast cancers on mammography, and lung cancers from tissue slides.⁶ An AI based system has even surpassed trained dermatologists in differentiating between benign and malignant skin conditions.⁷ Similarly, in the area of preoperative patient risk stratification, a ML based system has outperformed

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traditional surgical risk assessment tools, such as the ACS-NSQIP Calculator.

All major industries now use cloud computing to store and manage data. Dropbox, iCloud and OneDrive are cloud-based platforms with millions of users worldwide. Files, multimedia and photographs can be stored in a central 'cloud' (analogous to a brain) and accessed globally without geographical boundaries. The next-generation surgical robotic systems are being developed to use cloud as a computing platform. Clinical and skills-based data on operations performed by surgeons using the robot will be fed to this central computer-brain. As more data from more robots gets routed to the cloud, ML models will analyze it to develop best practices in conducting an operation efficiently and safely. A surgeon using a robot to perform an operation anywhere in the world will have access to this collective knowledge in real time. The possibilities are endless, from providing a step-by-step navigation (Surgical GPS) through complex surgical procedures to identifying critical anatomical structures like blood vessels, ureters or bile ducts, thereby protecting them from iatrogenic injury. The end result is a tremendous enhancement in surgical safety.

It is evident that robots are only one part of this digital surgical revolution. Cloud-based computing, AI, ML and ultra-reliable 5G networks will collectively open the door to this new era of digital surgery. These fascinating developments require significant investment, both in terms of capital and on-going training. Surgeons practising in resource-constrained environments already face many challenges, and this places them at a further disadvantage. For example, Pakistan will not roll out its first 5G network till 2021 at the earliest. There is only one functional da Vinci Si robot in Karachi, a joint initiative of Civil Hospital and the Sindh Institute of Urology and Transplantation (SIUT). A significant roadblock to

progress has been Intuitive Surgical Inc, which presently has a near-monopoly on the global robot market. For the last several years, they have put a moratorium on further robot sales to Pakistan based on the failure of earlier programmes to launch effectively. This is deeply concerning when you consider that in neighbouring India there is an ever-expanding network of state-of-the-art robotic surgery centers.

This technological apartheid is not justified. South Asia faces common challenges in delivering surgical care to its inhabitants.⁸ The promise of a regional collaborative surgical community will only be realized once these barriers to accessing technology are removed.

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